

Department of Civil and Environmental Engineering

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Professors Emeriti:	Abboud-Klink, Sami; Iliya, Raja; Hope, Edward
Associate Professor:	Inglessis, Constantine
Assistant Professors:	Assaf, Hamed; Najjar, Shadi; Saikaly, Pascal
Senior Lecturers:	Azar, Kamal; Basha, Hisham
Lecturers:	Fawwaz, Youssef; Hamdan, Fadi; Kasti, Fuad; Kasti, Najib; Nader, Halim; Sadeck, Salah EL-Dinn; Semerjian, Lucy
Instructors:	Abboud, Antoine; EL Meski, Fatima; Hasbini, Hayssam; Jabakhanji, Rami; Nehme, Elias

Undergraduate Programs

The Department of Civil and Environmental Engineering (CEE) offers the degrees of Bachelor of Engineering (BE): major, Civil Engineering (CE) and Bachelor of Science (BS): major, Construction Engineering (ConsE).

The mission of the undergraduate programs of the CEE department is to provide a stimulating and supportive environment for high-standard education; to prepare graduates for a lifelong productive career in addressing problems in a rapidly-changing world, while instilling in them an appreciation of leadership qualities, professionalism, and ethics; to provide professional services of the highest quality to the community; and to contribute to expanding the knowledge and technological base in civil and environmental engineering.

Bachelor of Engineering (BE), Specialization: Civil Engineering (CE)

Program Educational Objectives

The program is based on the following set of educational objectives:

- To impart a sound understanding of the fundamental principles and concepts of civil and environmental engineering while allowing sufficient specialization in sub-disciplines: structural, geotechnical, transportation, environmental and water resources engineering
- To develop the engineering principles and the mathematical, scientific, and computational skills in formulating and solving civil and environmental engineering problems

- To cultivate the skills pertinent to the engineering design process, conduct of experiments, analysis, and interpretation of data
- To expose students to real-world problems that consider multi-disciplinary approaches while addressing relevant social, environmental, economic, and aesthetic concerns
- To encourage independent thinking and the use of novel technologies to meet technical challenges and advance creative solutions
- To develop effective teamwork and communication skills
- To promote issues of professional and ethical conduct to prepare students for leading roles in the profession and the community

Curriculum

Term I (Fall)			Credits
CIVE	200	Introduction to Civil Engineering	2
EECE	230	Introduction to Programming	3
MATH	201	Calculus and Analytical Geometry III	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
Arabic Elective			3
			Total 15

Term II (Spring)			Credits
CIVE	210	Statics	3
EECE	210	Electric Circuits	3
MECH	220	Engineering Graphics	1
MATH	202	Differential Equations	3
ENGL	206	Technical English	3
Ethics Elective (PHIL 205, PHIL 206, PHIL 209, PHIL 210, or Approved Ethics)			3
			Total 16

Term III (Summer)			Credits
CIVE	360	Surveying	2
STAT	230	Introduction to Probability and Random Variables	3
Humanities Elective			3
			Total 8

Term IV (Fall)			Credits
CIVE	310	Mechanics of Materials	3
CIVE	320	Construction Materials and Technologies	2
CIVE	350	Environmental Engineering	3
CIVE	370	Introduction to Information Technology	3
MATH	251	Numerical Computing	3
Humanities Elective			3
			Total 17

Term V (Spring)			Credits
CIVE	311	Structures I	3
CIVE	340	Fluid Mechanics and Laboratory	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introductory Chemical Techniques	2
Biology Elective or			
CIVE	351	Environmental Microbiology	3
Humanities Elective			3
			Total 17

Term VI (Summer)			Credits
CIVE	430	Engineering Geology	3
ENMG	400	Engineering Economy	3
English Elective			3
			Total 9

Term VII (Fall)			Credits
CIVE	410	Structures II	3
CIVE	420	Concrete I	3
CIVE	440	Hydraulics and Laboratory	3
CIVE	460	Highway Engineering	3
Math Elective (MATH 212, MATH 218, MATH 281, or an approved math course)			3
			Total 15

Term VIII (Spring)			Credits
CIVE	421	Concrete II	3
CIVE	431	Soil Mechanics and Laboratory	3
CIVE	441	Engineering Hydrology	3
CIVE	450	Water and Wastewater Treatment and Laboratory	3
CIVE	461	Transportation Engineering and Laboratory	3
			Total 15

Term IX (Summer)			Credit
CIVE	500	Approved Experience	1b.*

*b. stands for billing

Term X (Fall)			Credits
CIVE	501	Final Year Project I	1
CIVE	530	Foundation Engineering	3
CIVE	580	Construction Management	3
Technical Elective I			3
Technical Elective II			3
Social Sciences Elective			3
			Total 16

Term XI (Spring)			Credits
CIVE	502	Final Year Project II	3
Technical Elective III			3
Technical Elective IV			3
Economics Elective			3
Social Sciences Elective			3
			Total 15
Total = 143 credit hours			

Technical Electives of Term X and Term XI

- CIVE 503 Special Topics in Civil and Environmental Engineering
- undergraduate (500 series) or graduate (600 series) courses in Civil and Environmental Engineering
- approved courses from other departments

Bachelor of Science (BS), Specialization: Construction Engineering (ConsE)

Program Educational Objectives

The program is based on a set of educational objectives that fall under the following themes:

Civil Engineering – Fundamentals and Design

- To impart a sound understanding of the fundamental principles and concepts of civil engineering.
- To impart the knowledge of basic and applied engineering design used in the construction industry, and in the specialty field of construction engineering.

Construction Engineering – Basic Skills, Principles, and Technologies

- To help students develop the engineering principles and the mathematical, scientific, and computational skills required to formulate and solve construction engineering problems which include construction planning, processes, methods, materials, equipment, safety, and cost.
- To encourage independent thinking and the use of novel technologies in order to propose creative solutions and meet technical challenges.

Construction Engineering - Professional and Business Context

- To prepare students for leading roles in the profession and the community by promoting issues of professional and ethical conduct.
- To impart an understanding of management concerns in construction such as economics, business, statistics, leadership, and decision methods.
- To instill in students the interpersonal, teamwork and communication skills necessary to perform professionally and make sound decisions in conditions of risk and uncertainty.

Contemporary Issues and Social Context

- To equip students with the ability to use modern experimental and computational tools in the design and evaluation of the economic, environmental, and social impact of construction engineering solutions.
- To develop in students the ability to integrate construction engineering fundamentals with contemporary applications and issues facing the construction industry.

Curriculum

Term I (Fall)			Credit Hours
CIVE	200S	Introduction to Civil/Const. Engineering	2
CIVE	210	Statics	3
CIVE	370S	Introduction to Information Technology	4
MATH	201	Calculus and Analytical Geometry III	3
ENGL	206	Technical English	3
			Total 15

Term II (Spring)			Credit Hours
CIVE	310	Mechanics of Materials	3
MECH	220	Engineering Graphics	2
EECE	210	Electric Circuits	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
Arabic Elective			3
			Total 15

Term III (Summer)			
CIVE	361	Surveying for Construction Engineering	3
STAT	230	Introduction to Probability and Random Variables	3
		Humanities Elective	3
			Total 9
Term IV (Fall)			
Math	251	Numerical Computing	3
CIVE	321	Construction Materials and Quality Control	3
CIVE	350	Environmental Engineering	3
CIVE	460	Highway Engineering	3
CIVE	481	Construction Planning and Scheduling	3
			Total 15
Term V (Spring)			
CIVE	311	Structures I	3
CIVE	340	Fluid Mechanics and Laboratory	3
CIVE	431	Soil Mechanics and Laboratory	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introductory Chemical Techniques	2
		Social Science Elective	3
			Total 17
Term VI (Summer)			
		Ethics (PHIL 206, PHIL 209, or PHIL 210)	3
ECON	212	Elementary Macroeconomic Theory	3
		Humanities Elective	3
			Total 9
Term VII (Fall)			
CIVE	480	Construction Management	3
CIVE	420	Concrete I	3
CIVE	440	Hydraulics and Laboratory	3
		Free Construction Engineering Elective	3
		Free CEE Elective	3
			Total 15
Term VIII (Spring)			
CIVE	482	Construction Operations	3
ARCH	242S	Building Construction	3
		Free Construction Engineering Elective	3
		Free CEE Elective	3
		Humanities Elective	3
			Total 15
Total = 110 credit hours			

Course Descriptions

CIVE 200 Introduction to Civil Engineering 2 cr.

An introductory course to the world of civil engineering including significant developments in the field, both current and future. The course gives an overview of civil engineering as a profession covering aspects of concept, design, and execution through seminars, case studies, field trips, laboratory experimentation, and a hands-on group project. *Annually.*

CIVE 200S Introduction to Civil/Construction Engineering (ConsE) 2 cr.

An introductory course to the world of civil engineering including significant developments in the field, with special emphasis on construction engineering. The course gives an overview of civil engineering as a profession covering aspects of concept, design, and execution through seminars, case studies, field trips, laboratory experimentation, and a hands-on group project. *Annually.*

CIVE 210 Statics 3 cr.

A course outlining vector mechanics of forces and moments; free-body diagrams; equilibrium of particles and rigid bodies in two and three dimensions; plane and space trusses; frames and machines; axial, shear, and moment diagrams of beams and simple frames; friction; center of gravity and centroid; area moment of inertia; computer applications. *Pre- or corequisite: MATH 201. Every regular term.*

CIVE 310 Mechanics of Materials 3 cr.

A course on stresses, strains, and stress-strain relationship; tension and compression; torsion of circular bars; bending and shear stresses in beams; combined stresses; stress transformation and Mohr's circle. *Prerequisite: CIVE 210. Annually.*

CIVE 311 Structures I 3 cr.

An introductory course covering influence lines; deflection of beams and frames by double integration method, moment-area theorems, and conjugate beam; introduction to indeterminate structures; approximate analysis of building frames. *Prerequisite: CIVE 310. Annually.*

CIVE 320 Construction Materials and Technologies 2 cr.

A course that covers the composition and properties of engineering construction materials through hands-on laboratory experiments. The course introduces students to developments in construction equipment and technologies and includes field demonstrations. *Annually.*

CIVE 321 Construction Materials and Quality Control 3 cr.

A course that covers materials used in construction; physical and mechanical properties of construction materials such as asphalt, pavement base materials, Portland cement concrete, steel, polymers, wood, aluminum, and advanced composite materials; proportioning of concrete mixtures including admixtures; and hands on laboratory experiments and demonstrations to familiarize students with testing methods, equipment, standards, and quality control procedures. *Annually.*

CIVE 340 Fluid Mechanics and Laboratory 3 cr.

A course that deals with fluid properties, fluid static, continuity equation, Bernoulli's equation, energy principle, momentum principle, laboratory experiments. *Annually.*

CIVE 350 Environmental Engineering 3 cr.

A course that introduces the fundamentals of environmental engineering. A screening course of major topics in environmental engineering including water and wastewater, environmental hydrology, environmental hydraulics and pneumatics, air, solid waste, noise, environmental modeling, and hazardous waste. *Annually.*

- CIVE 351 Environmental Microbiology 3 cr.**
A course that introduces the basic principles of environmental microbiology and discusses example applications from the natural and engineered worlds. The main goals of this course are to present an overview of important micro-organisms involved in environmental systems, their ecology, their interactions with various pollutants, and their beneficial or harmful effects on humans. *Prerequisites:* CHEM 202 (or equivalent), MATH 201 (or equivalent). *Annually.*
- CIVE 360 Surveying 2 cr.**
A course on the theory of measurements and errors; linear measurements; surveying instruments; leveling; angles, bearings, and azimuths; stadia measurements; traversing–field aspects; traverse computations and adjustment; topographic surveying; triangulation. *Annually.*
- CIVE 361 Surveying for Construction Engineering 3cr.**
A course on the theory of measurements and errors; linear measurements; surveying principles and instruments; leveling; angles, bearings, and azimuths; stadia measurements; traversing–field aspects; traverse computations and adjustment; topographic surveying; triangulation; fundamentals of surveying for building and infrastructure construction; setting out horizontal and vertical curves; setting out engineering structures and construction projects. *Annually.*
- CIVE 370 Introduction to Information Technology 3 cr.**
An introductory course on computer hardware. This course covers Internet technology, database systems, and the use of software tools and their integration into projects to create, manage, and exchange information with reference to civil and environmental engineering applications. *Annually.*
- CIVE 370S Introduction to Information Technology (ConSE) 4 cr.**
A course introducing students to the main features of Information Technology (IT) with emphasis on applications to civil engineering. This course covers several software applications and programming tools including: FrontPage, Excel, VBA, Access, Visio, and database technology. The course also introduces students to basic programming skills using Matlab. *Annually.*
- CIVE 410 Structures II 3 cr.**
A course on the stability and determinacy of structures; energy theorems and applications to trusses, beams, and frames; solution of statically indeterminate structures by flexibility (force) and stiffness methods; introduction to the direct stiffness method; influence lines for indeterminate structures. *Prerequisite:* CIVE 311. *Annually.*
- CIVE 420 Concrete I 3 cr.**
A course that covers the mechanical properties of concrete materials; ultimate strength theory of flexure and shear; flexural and shear design of beams; service load behavior; bond properties of reinforcing bars; design of solid and ribbed one-way slabs. *Prerequisite:* CIVE 311. *Annually.*
- CIVE 421 Concrete II 3 cr.**
A course that builds upon Concrete I and covers continuous beams; short columns, slender columns, and biaxially bent columns; wall footings, concentrically and eccentrically loaded single column footings, and combined footings; staircases; bearing walls; cantilever retaining walls; two-way slabs. *Prerequisites:* CIVE 410 and CIVE 420. *Annually.*
- CIVE 430 Engineering Geology 3 cr.**
A course that discusses the composition and properties of rocks; geologic processes; geologic hazards; geologic structures and engineering consequences; terrain analysis and geologic mapping; interpretation and use of geologic maps; application of geology to engineering practice. *Annually.*

- CIVE 431 Soil Mechanics and Laboratory 3 cr.**
A course on soil classification and index properties; soil structure and moisture; compaction; seepage; effective stress concept; compressibility and consolidation; stress and settlement analysis; shear strength. Laboratory tests are conducted to familiarize students with soil characterization and the engineering behavior of soils. *Prerequisite:* CIVE 310. *Annually.*
- CIVE 440 Hydraulics and Laboratory 3 cr.**
Flow in conduits, flow in open channels, flow measurements, and laboratory experiments. *Prerequisite:* CIVE 340. *Annually.*
- CIVE 441 Engineering Hydrology 3 cr.**
A course outlining hydrologic principles, rainfall-runoff analysis, flood routing, frequency analysis, and ground water hydrology. *Annually.*
- CIVE 450 Water and Wastewater Treatment and Laboratory 3 cr.**
A course that examines the quality and treatment methods of water and wastewater; testing for physical, chemical, and biological parameters. *Prerequisite:* CIVE 350. *Annually.*
- CIVE 460 Highway Engineering 3 cr.**
A course that examines road vehicle performance; principles of geometric design and highways; horizontal and vertical alignment; earthwork; intersections and interchanges; parking facilities; basic traffic models; queuing theory and traffic analysis; travel demand forecasting. *Prerequisite:* CIVE 360. *Annually.*
- CIVE 461 Transportation Engineering and Laboratory 3 cr.**
A course that introduces the field of transportation engineering through a presentation of the basics of traffic engineering, traffic flow theory, and pavement design. The laboratory component consists of carefully structured experiments that reinforce students' understanding of the academic concepts and principles. *Prerequisite:* CIVE 460. *Annually.*
- CIVE 480/580 Construction Management 3 cr.**
A course on organizing for construction projects; pre-construction activities; bidding and contracts; fundamentals of construction planning, scheduling, monitoring, and control; application of construction control tools: CPM, materials management, operations analysis, and quality control; Project delivery system; Safety, labor and professional ethics. *Annually.*
- CIVE 481 Construction Planning and Scheduling 3 cr.**
A course that offers an investigation of the planning activities for construction projects and scheduling techniques used in construction; resource analysis: selection, time schedule, and costing for labor, materials and equipment; scheduling: precedence diagrams, Critical Path Method (CPM), Program Evaluation Review Techniques (PERT), and computer applications (Primavera). It covers the basic concepts and methodology for making rational decisions in the design and implementation of real construction projects. *Annually.*
- CIVE 482 Construction Operations 3 cr.**
A course on planning for construction operations; design and analysis of construction operations; productivity and resource use considerations; site layout design and analysis; use of quantitative methods and queuing theory; effects of new technologies on construction operations; introduction to construction automation; types and uses of construction equipment; equipment productivity and costs. *Annually.*

CIVE 530 Foundation Engineering 3 cr.
A course that covers site investigations; evaluation of data from field and laboratory tests; estimation of stresses in soil masses; applications of principles of soil mechanics to determination of bearing capacity and settlement of spread footings, mats, single piles, and pile groups. *Prerequisite: CIVE 431. Annually.*

CIVE 581 Specifications and Cost Estimation 3 cr.
A course on the structure of construction documents and their interrelationships; bidding requirements; general and particular contract conditions; administrative and procedural requirements for construction; technical specifications; construction cost estimation processes; and unit rates determination and pricing. *Annually.*

CIVE 583 Construction Business Management and Financing 3 cr.
A course that covers the principles of business management of construction companies – theory as well as international and regional practice; an overview of construction business operations including strategic planning, organizational structure, marketing, accounting, financing, risk analysis, and quality; and the principles and sources of construction funding for contracting firms and projects.

CIVE 584 Selection and Utilization of Construction Equipment 3 cr.
A course that covers construction equipment categories, capabilities and limitations; selection and utilization of construction equipment for buildings, excavation, earthworks, roads, tunnels and dams; cost analysis of equipment and assembly techniques; fleet operations, maintenance programs, methods, and procedures; modeling and simulation of construction equipment for planning and feasibility assessment.

CIVE 586 Construction Methods and Safety 3 cr.
A course on construction methods for civil/structural facilities including soil excavations, soil improvement and stabilization; design of formworks for concrete buildings and bridge structures; types of concrete construction (pre-cast, in-situ); steel construction (installation methods, equipment); safety and inspection requirements for construction sites and projects; inspection for safety and hazards, environmental issues and quality.

CIVE 589 Infrastructure Construction and Evaluation 3 cr.
A course that covers the urban requirements, engineering technologies, and procedures for the construction of infrastructure facilities including: roads and pavements, bridges, water and sanitary networks, electric power lines, and telephone/communication lines. It also covers applications to urban and rural areas; nondestructive evaluation techniques for infrastructure systems; accelerated and full-scale testing; instrumentation, video logging, remote sensing, and nanotechnology.

Special Courses

CIVE 500 Approved Experience 1 b.

CIVE 501 Final Year Project I 1 cr.
A chosen design topic and preparation of a detailed execution program for CIVE 502, through comprehensive research with the guidance and approval of the faculty. *Annually.*

CIVE 502 Final Year Project II 3 cr.
A supervised project in groups of normally three students aimed at providing practical design experience in a civil and environmental engineering application. *Prerequisite: CIVE 501. Annually.*

CIVE 503 Special Topics in Civil and Environmental Engineering 3 cr.

Structural Sequence

CIVE 610 Advanced Structural Analysis 3 cr.
A course that offers a review of matrix algebra; basic principles of structural analysis: stiffness, flexibility, and energy methods; direct stiffness method for plane and space trusses and frames; linear and non-linear problems; special problems; and computer programming. *Prerequisite: CIVE 410. Annually.*

CIVE 620 Plain Concrete 3 cr.
A course that examines portland cements; aggregates; fly ash and silica fume; admixtures for concrete; proportioning normal concrete mixtures; pumping concrete; consolidating, finishing, and curing concrete; durability; testing hardened concrete; high-strength concrete; light and heavy weight concretes; hot and cold weather concreting. *Prerequisite: advanced standing level. Annually.*

CIVE 621 Special Topics in Concrete 3 cr.
A course that reviews reinforced concrete design; wind load on structures; seismic design of structures; design of shear walls; brackets, corbels, and deep girders; torsion in concrete members; circular, rectangular, and elevated water tanks; spherical, conoidal, and ellipsoidal domes. *Prerequisite: CIVE 421. Annually.*

CIVE 622 Prestressed Concrete 3 cr.
A course on material characteristics; prestress losses; working strength design procedures; composite construction; ultimate flexural strength and behavior; shear design; continuous prestressed concrete members. *Prerequisite: CIVE 421. Alternate years.*

CIVE 623 Bridges 3 cr.
A course that discusses types of bridges; influence lines; loads and their distribution on bridges; serviceability of bridges; methods of design of bridge deck, superstructure, and substructure. *Prerequisites: CIVE 410 and CIVE 421. Alternate years.*

CIVE 624 Steel Design 3 cr.
A course that examines loads on structures; philosophies of design: LRFD versus ASD; behavior, analysis, and design (according to AISC) of tension members, bolted connections, welded connections, compression members, and beams. *Prerequisite: CIVE 410. Alternate years.*

CIVE 625 Strengthening and Rehabilitation of Concrete Structural Systems 3 cr.
A course on assessment of structural deficiency using analytical and field test methods; strengthening materials; strengthening of structural members in flexure, shear, and axial load; upgrading of gravity load-designed members for earthquake load resistance. *Prerequisite: advanced standing level. Alternate years.*

CIVE 626 Earthquake Engineering 3 cr.
A course that examines the nature of earthquake ground motion; seismic hazard evaluation in engineering practice; response analysis of structures and effect of soil conditions on structural response and behavior under earthquake ground motion; design of structures under earthquake loading. *Alternate years.*

CIVE 632 Reliability Based Design of Civil Systems 3 cr.
A course that covers applications of reliability theory with regards to assessing the safety and reliability of civil systems in the presence of uncertainty; decision making and risk analysis; definition of the probability of failure; modeling uncertainty in resistance and load; limit states and limit state functions; approximate and exact methods for assessing reliability; load and resistance factor design (LRFD) in structural and geotechnical engineering; basics of design code calibration; reliability assessments of existing structures, updating reliability with load tests. *Prerequisite: advanced standing level. Alternate years.*

Geotechnical Sequence

CIVE 630 Applied Foundation Engineering 3 cr.
A course on braced excavations, retaining structures, deep foundations, slope stability, and computer applications. *Prerequisite: CIVE 530. Alternate years.*

CIVE 631 Environmental Geotechnics 3 cr.
A course on geotechnical practice in environmental protection and restoration; methods of soil and site characterization for sifting of waste repositories and site restoration; influence of physical and chemical processes in soils on the evaluation of contaminant distribution; design of waste containment systems including landfills, slurry walls, and soil stabilization; the applicability and use of geosynthetics; and technologies for site restoration and cleanup. *Prerequisite: CIVE 431.*

CIVE 633 Soil Behavior 3 cr.
A course on soil mineralogy, soil formation, and composition; influence of geological factors on properties; colloidal phenomena in soils; soil structure; analysis of conduction phenomena (hydraulic, diffusive, thermal, and electrical); compressibility, strength, and deformation properties. *Prerequisite: CIVE 431.*

CIVE 634 Soil and Site Improvement 3 cr.
A course that covers compaction, admixture stabilization, foundation soil treatment, reinforced soil and composite materials, and material sites reclamation. *Alternate years.*

Environmental and Water Resources Sequence

CIVE 640 Hydraulic Structures 3 cr.
A course that covers closed conduit flow, water distribution systems, transient analysis, open channel flow, flood control, culvert hydraulics, design of various hydraulic structures. *Prerequisite: CIVE 440. Alternate years.*

CIVE 641 Surface Water Hydrology 3 cr.
A course on design storm, rainfall-runoff modeling, overland flow, flood routing, reservoir routing, simulation models, hydrologic design, urban hydrology, and stochastic hydrology. *Prerequisite: CIVE 441 or equivalent. Annually.*

CIVE 642 Groundwater Hydrology 3 cr.
A course that deals with properties of groundwater, groundwater movement, general flow equations, steady-state well hydraulics, seepage forces, unsteady well hydraulics, infiltration, and groundwater modeling. *Prerequisite: CIVE 441. Annually.*

CIVE 643 Hydraulics of Open Channels 3 cr.
A course that examines gradually varied flow theory and analysis, spatially varied flow, and numerical modeling of unsteady flow in open-channels. *Prerequisite: CIVE 440. Alternate years.*

CIVE 644 Coastal Engineering 3 cr.
A course on small-amplitude wave theory, finite-amplitude wave theory, conoidal waves, solitary wave theory, wave refraction, diffraction, and reflection, wave forces, and design of maritime structures (e.g., breakwaters). *Prerequisite: CIVE 440. Alternate years.*

CIVE 645 Transport Phenomena in Surface and Subsurface Waters 3 cr.
A course on advection, diffusion, and dispersion of pollutants; transport in rivers and estuaries; transport in groundwater; numerical modeling; design of wastewater discharge system. *Prerequisite: advanced standing level.*

CIVE 646 Water Resource Systems: Planning and Management 3 cr.
A course that introduces the main concepts and principles of water resources planning and management; logical steps in engineering planning and decision making; water resource systems analysis, modeling, simulation, and optimization; economic and financial analysis; flood protection and reservoir operation; and water resources management case studies. *Prerequisite: advanced standing level. Alternate years.*

CIVE 647 GIS for Water Resources and Environmental Engineering 3 cr.
A course that introduces the concepts and principles of Geographic Information Systems (GIS) from the perspective of water resources and environmental engineering. It provides coverage of state-of-the-art GIS methods and tools, specifically targeting water resources and environmental applications including: spatial and terrain analysis, geostatistical analysis, watershed delineation and identification of river networks, representation of groundwater and aquifer systems, time series analysis, and development of GIS integrated water and environmental models. *Prerequisite: advanced standing level. Alternate years.*

CIVE 650 Methods of Environmental Sampling and Analysis 3 cr.
A course on sampling techniques and instrumental methods in environmental sciences; determination of pollutants in water, air, and soil; analytical techniques; adaptation of procedures to specific matrices; case studies. *Prerequisite: advanced standing level. Alternate years.*

CIVE 651 Environmental Chemistry and Microbiology 3 cr.
A course that deals with organic, inorganic, and physical chemistry; chemical equilibrium; reaction kinetics; acidity, alkalinity; composition, morphology, and classification of micro-organisms; energy, metabolism, and synthesis; growth, decay, and kinetics; and biological water quality indicators. *Prerequisite: CHEM 202, BIOL 210, or equivalent. Alternate years.*

CIVE 652 Environmental Management and Decision Making 3 cr.
A course that deals with mathematical programming techniques, multi-objective optimization, and the generation of alternatives, as these are used in environmental systems analysis and management; as well as introducing how considerations such as economics, uncertainty, equity, and other sociopolitical parameters may influence environmental management and decision making. *Prerequisite: advanced standing level. Alternate years.*

CIVE 653 Water and Sewage Works Design 3 cr.
A course that examines the design of water and wastewater schemes, including design reports and a literature search on the development of conventional treatment processes. *Prerequisite: CIVE 450. Alternate years.*

CIVE 654 Solid Waste Management I 3 cr.
A course on nature and effects of solid wastes including hazardous wastes; engineering management principles, practices, and techniques for management of solid wastes administration; solid waste generation, storage, collection and transport, processing, resource recovery, and disposal; and trip to a local facility. *Prerequisite: advanced standing level. Annually.*

CIVE 655 Solid Waste Management II 3 cr.
A course on the design of solid waste disposal schemes, including design reports and a literature search on the development of conventional treatment and disposal processes. *Prerequisite: CIVE 654 or consent of instructor. Alternate years.*

CIVE 656 Air Pollution and Control I 3 cr.
An introductory course on air pollutants, sources, and effects; emissions estimates, regulations, and monitoring techniques; particulate matter characterization; meteorology and atmospheric dispersion; and air pollution control processes. *Prerequisite: CHEM 202 or equivalent. Annually.*

CIVE 657 Air Pollution and Control II 3 cr.
A course that examines process analysis, operational limitations, cost and performance, and evaluation of control process and equipment; and case studies, field visits, and inspection of industrial installations. *Prerequisite: CIVE 656 or consent of instructor. Alternate years.*

CIVE 658 Industrial/Hazardous Waste Management 3 cr.
A course that deals with sources, quantity, and quality of industrial wastes; basic industrial waste treatment processes; major industries, types of wastes, and existing treatment practices; disposal and fate of industrial wastes. *Prerequisites: CIVE 450 and CIVE 651, or consent of instructor. Alternate years.*

CIVE 659 Environmental Impact Assessment 3 cr.
A course that outlines theories and procedures of assessing environmental impact; analysis of the impact of development on various measures of environmental quality; and benefit-cost considerations in environmental impact assessment. *Prerequisites: CIVE 450, CIVE 654, and CIVE 656; or consent of instructor. Alternate years.*

Transportation Sequence

CIVE 660 Pavement Design 3 cr.
A course examining highway and airport pavement design; flexible and rigid pavement types and wheel loads; stresses in flexible and rigid pavements; pavement behavior under moving loads; soil stabilization. *Prerequisite: CIVE 461. Alternate years.*

CIVE 661 Urban Transportation Planning I 3 cr.
An introductory course on methods and models used in transportation planning with emphasis on the urban context. *Prerequisite: CIVE 461. Alternate years.*

CIVE 662 Traffic Engineering 3 cr.
A course outlining traffic engineering studies; traffic control of signalized and unsignalized intersections; signal control hardware and maintenance; arterial performance and operations; and network optimization. *Prerequisite: CIVE 461. Alternate years.*

CIVE 663 Transportation Systems Analysis 3 cr.
A course on transportation and traffic problems in modern society. Among the topics covered are travel forecasting problems and methods; theoretical techniques for traffic flow description and management; highway, railway, and runway capacity and performance characteristics; economic considerations; and cost functions. *Prerequisite: advanced standing level. Alternate years.*

CIVE 664 Design and Management of Transport Operations 3 cr.
A course that covers the application of quantitative techniques from operations research and probabilistic analysis to transportation problems. Applications covered include: pickup and delivery systems, emergency urban services, facility location, and network problems. *Prerequisite: STAT 230 or equivalent.*

CIVE 665 Transportation Economics 3 cr.
A course that investigates the application of economic principles to the evaluation of projects and policies in the transport sector such as transport project benefits, costs, and financing, and pricing in the transport sector. *Prerequisite: advanced standing level. Alternate years.*

CIVE 666 Transport Operations 3 cr.
A course that introduces probabilistic and optimization methods for designing efficient operations in freight carrier, airline, transit, and traffic modes. Topics include crew and vehicle scheduling in freight, airline, and transit modes; vehicle routing problems in carrier systems; runway and air traffic operations; operations control in transit services; and fundamental relations and models of traffic flow. *Prerequisite: CIVE 461.*

Common Courses

CIVE 670 Computer Methods in Civil Engineering 3 cr.
A course on the use of the computer for analysis, design, and decision making in civil engineering, including programming, numerical, and CAD methods and applications. *Prerequisites: EECE 230 and CIVE 370. Alternate years.*

CIVE 671 Numerical Modeling 3 cr.
A course that deals with ordinary differential equations: initial-, boundary-, and characteristic-value problems; partial differential equations: steady state, time dependent, and oscillatory problems; techniques: Runge-Kutta, shooting, iterative, finite difference, and finite element methods. *Prerequisite: advanced standing level. Alternate years.*

CIVE 672 Introduction to Geographic Information Systems 3 cr.
An introductory course on Geographic Information Systems (GIS) and their applications in the planning and engineering fields, alternatives in computer-based graphics, data concepts and tools, network data management and planning applications, and implementation issues. This course satisfies the departmental requirements in all graduate engineering programs. *Annually.*

CIVE 673 Infrastructure Systems Management 3 cr.
A course on modeling and optimization methods and their application to inspection, performance prediction and maintenance decision making for the management of infrastructure systems. *Annually.*